

TRANSMITTAL LETTER TO THE UNITED STATES  
DESIGNATED/ELECTED OFFICE (DO/EO/US)  
CONCERNING A FILING UNDER 35 U.S.C. 371

0020-4783P

U.S. APPLICATION NO. (If known, see 37 CFR 1.5)

09/719138  
NEW

INTERNATIONAL APPLICATION NO.

PCT/JP00/02300

INTERNATIONAL FILING DATE

PTO/PCT Rec'd 08 DEC 2000  
April 10, 2000

PRIORITY DATE CLAIMED

April 8, 1999

## TITLE OF INVENTION

HEAT-TRANSFER PIPE WITH INTERNAL GROOVES AND MANUFACTURING METHOD AND MANUFACTURING \*\*

## APPLICANT(S) FOR DO/EO/US

FUJINO, Hirokazu; KASAI, Kazushige; AKAI, Kanji; OKAMOTO, Noriaki; UCHIMITSU, Masaru

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. ☒ This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.
2. ☐ This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.
3. ☒ This express request to begin national examination procedures (35 U.S.C. 371(f)) at any time rather than delay examination until the expiration of the applicable time limit set in 35 U.S.C. 371(b) and PCT Articles 22 and 39 (1).
4. ☐ A proper Demand for International Preliminary Examination was made by the 19<sup>th</sup> month from the earliest claimed priority date
5. ☒ A copy of the International Application as filed (35 U.S.C. 371(c)(2))
- a. ☐ is transmitted herewith (required only if not transmitted by the International Bureau).
- b. ☒ has been transmitted by the International Bureau. WO 00/62001
- c. ☐ is not required, as the application was filed in the United States Receiving Office (RO/US).
- ☒ A translation of the International Application into English (35 U.S.C. 371(c)(3)).
- ☒ Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371(c)(2)).
- a. ☐ are transmitted herewith (required only if not transmitted by the International Bureau).
- b. ☐ have been transmitted by the International Bureau.
- c. ☐ have not been made; however, the time limit for making such amendments has NOT expired.
- d. ☒ have not been made and will not be made.
- ☐ A translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).
- ☐ An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)).
10. ☐ A translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).

Items 11. to 16. below concern document(s) or information included:

11. ☒ An Information Disclosure Statement under 37 CFR 1.97 and 1.98.-1449 and International Search Report w/ cited documents
12. ☐ An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
13. ☒ A **FIRST** preliminary amendment.  
☐ A **SECOND** or **SUBSEQUENT** preliminary amendment.
14. ☐ A substitute specification.
15. ☐ A change of power of attorney and/or address letter.
16. ☒ Other items or information:  
PCT/ISA/210  
Nine (9) sheets of formal drawings

\*\*DEVICE THEREFOR

U.S. APPLICATION NO (if known, see 37 CFR 1.5)		INTERNATIONAL APPLICATION NO		ATTORNEY'S DOCKET NUMBER	
<div style="display: flex; justify-content: space-between;"> <span>NEW</span> <span>533 Rec'd PCT/PTO 08 DEC 2000</span> </div> <div style="font-size: 2em; font-weight: bold; margin-top: 5px;">09/719138</div>		PCT/JP00/02300		0020-4783P	

<p>17. <input checked="" type="checkbox"/> The following fees are submitted:</p> <p><b>BASIC NATIONAL FEE (37 CFR 1.492(a)(1)-(5):</b>          Neither international preliminary examination fee (37 CFR 1.482)          nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO          and International Search Report not prepared by the EPO or JPO. .... <b>\$1,000.00</b></p> <p>International preliminary examination fee (37 CFR 1.482) not paid to          USPTO but International Search Report prepared by the EPO or JPO ..... <b>\$860.00</b></p> <p>International preliminary examination fee (37 CFR 1.482) not paid to USPTO          but international search fee (37 CFR 1.445(a)(2)) paid to USPTO. .... <b>\$710.00</b></p> <p>International preliminary examination fee (37 CFR 1.482) paid to USPTO          but all claims did not satisfy provisions of PCT Article 33(1)-(4) ..... <b>\$690.00</b></p> <p>International preliminary examination fee (37 CFR 1.482) paid to USPTO          and all claims satisfied provisions of PCT Article 33(1)-(4). .... <b>\$100.00</b></p> <p style="text-align: center;"><b>ENTER APPROPRIATE BASIC FEE AMOUNT =</b></p> <p>Surcharge of <b>\$130.00</b> for furnishing the oath or declaration later than <input checked="" type="checkbox"/> 20 <input type="checkbox"/> 30          months from the earliest claimed priority date (37 CFR 1.492(e)).</p> <table border="1" style="width:100%; border-collapse: collapse; font-size: small;"> <tr> <th style="width: 20%;">CLAIMS</th> <th style="width: 20%;">NUMBER FILED</th> <th style="width: 20%;">NUMBER EXTRA</th> <th style="width: 20%;">RATE</th> <th style="width: 20%;"></th> <th style="width: 20%;"></th> </tr> <tr> <td>Total Claims</td> <td>7 - 20 =</td> <td>0</td> <td>X \$18.00</td> <td>\$</td> <td>0</td> </tr> <tr> <td>Independent Claims</td> <td>3 - 3 =</td> <td>0</td> <td>X \$80.00</td> <td>\$</td> <td>0</td> </tr> <tr> <td colspan="3">MULTIPLE DEPENDENT CLAIM(S) (if applicable) NO</td> <td>+ \$270.00</td> <td>\$</td> <td>0</td> </tr> <tr> <td colspan="4" style="text-align: right;"><b>TOTAL OF ABOVE CALCULATIONS =</b></td> <td>\$</td> <td>990.00</td> </tr> <tr> <td colspan="4">Reduction of 1/2 for filing by small entity, if applicable. Verified Small Entity statement must also be filed (Note 37 CFR 1.9, 1.27, 1.28).</td> <td>\$</td> <td>0</td> </tr> <tr> <td colspan="4" style="text-align: right;"><b>SUBTOTAL =</b></td> <td>\$</td> <td>990.00</td> </tr> <tr> <td colspan="4">Processing fee of <b>\$130.00</b> for furnishing the English translation later than <input type="checkbox"/> 20 <input type="checkbox"/> 30 months from the earliest claimed priority date (37 CFR 1.492(f)).</td> <td>\$</td> <td>0</td> </tr> <tr> <td colspan="4" style="text-align: right;"><b>TOTAL NATIONAL FEE =</b></td> <td>\$</td> <td>990.00</td> </tr> <tr> <td colspan="4">Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). <b>\$40.00</b> per property +</td> <td>\$</td> <td>0</td> </tr> <tr> <td colspan="4" style="text-align: right;"><b>TOTAL FEES ENCLOSED =</b></td> <td>\$</td> <td>990.00</td> </tr> <tr> <td colspan="4"></td> <td style="text-align: right;">Amount to be:</td> <td>\$</td> </tr> <tr> <td colspan="4"></td> <td style="text-align: right;">refunded</td> <td></td> </tr> <tr> <td colspan="4"></td> <td style="text-align: right;">charged</td> <td>\$</td> </tr> </table>	CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE			Total Claims	7 - 20 =	0	X \$18.00	\$	0	Independent Claims	3 - 3 =	0	X \$80.00	\$	0	MULTIPLE DEPENDENT CLAIM(S) (if applicable) NO			+ \$270.00	\$	0	<b>TOTAL OF ABOVE CALCULATIONS =</b>				\$	990.00	Reduction of 1/2 for filing by small entity, if applicable. Verified Small Entity statement must also be filed (Note 37 CFR 1.9, 1.27, 1.28).				\$	0	<b>SUBTOTAL =</b>				\$	990.00	Processing fee of <b>\$130.00</b> for furnishing the English translation later than <input type="checkbox"/> 20 <input type="checkbox"/> 30 months from the earliest claimed priority date (37 CFR 1.492(f)).				\$	0	<b>TOTAL NATIONAL FEE =</b>				\$	990.00	Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). <b>\$40.00</b> per property +				\$	0	<b>TOTAL FEES ENCLOSED =</b>				\$	990.00					Amount to be:	\$					refunded						charged	\$	<p><b>CALCULATIONS</b></p> <p><b>PTO USE ONLY</b></p>
CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE																																																																																		
Total Claims	7 - 20 =	0	X \$18.00	\$	0																																																																																
Independent Claims	3 - 3 =	0	X \$80.00	\$	0																																																																																
MULTIPLE DEPENDENT CLAIM(S) (if applicable) NO			+ \$270.00	\$	0																																																																																
<b>TOTAL OF ABOVE CALCULATIONS =</b>				\$	990.00																																																																																
Reduction of 1/2 for filing by small entity, if applicable. Verified Small Entity statement must also be filed (Note 37 CFR 1.9, 1.27, 1.28).				\$	0																																																																																
<b>SUBTOTAL =</b>				\$	990.00																																																																																
Processing fee of <b>\$130.00</b> for furnishing the English translation later than <input type="checkbox"/> 20 <input type="checkbox"/> 30 months from the earliest claimed priority date (37 CFR 1.492(f)).				\$	0																																																																																
<b>TOTAL NATIONAL FEE =</b>				\$	990.00																																																																																
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). <b>\$40.00</b> per property +				\$	0																																																																																
<b>TOTAL FEES ENCLOSED =</b>				\$	990.00																																																																																
				Amount to be:	\$																																																																																
				refunded																																																																																	
				charged	\$																																																																																

a. ☒ A check in the amount of \$ 990.00 to cover the above fees is enclosed.

b. ☐ Please charge my Deposit Account. No. \_\_\_\_\_ in the amount of \$ \_\_\_\_\_ to cover the above fees.  
 A duplicate copy of this sheet is enclosed.

c. ☒ The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any  
 overpayment to Deposit Account No. 02-2448.

**NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status.**

Send all correspondence to:  
**Birch, Stewart, Kolasch & Birch, LLP** or Customer No. 2292  
 P.O. Box 747  
 Falls Church, VA 22040-0747  
 (703)205-8000

SIGNATURE  
**SLATTERY, JAMES M.**  
 NAME  
 #28,380 (JMS)  
 REGISTRATION NO.

/rem D e c e m b e r 8, 2000

09/719138  
533 Rec'd PCT/PTO 08 DEC 2000  
PATENT  
0020-4783P

IN THE U.S. PATENT AND TRADEMARK OFFICE

Applicant: FUJINO, Hirokazu et al.  
Int'l. Appl. No.: PCT/JP00/02300  
Appl. No.: NEW Group:  
Filed: December 8, 2000 Examiner:  
For: HEAT-TRANSFER PIPE WITH INTERNAL  
GROOVES AND MANUFACTURING METHOD  
AND MANUFACTURING DEVICE THEREFOR

PRELIMINARY AMENDMENT

**BOX PATENT APPLICATION**

Assistant Commissioner for Patents  
Washington, DC 20231

December 8, 2000

Sir:

The following Preliminary Amendments and Remarks are respectfully submitted in connection with the above-identified application.

AMENDMENTS

IN THE SPECIFICATION:

Please amend the specification as follows:

Before line 1, insert --This application is the national phase under 35 U.S.C. § 371 of PCT International Application No. PCT/JP00/02300 which has an International filing date of April 10, 2000, which designated the United States of America.--


REMARKS

The specification has been amended to provide a cross-reference to the previously filed International Application.

If necessary, the Commissioner is hereby authorized in this, concurrent, and future replies, to charge payment or credit any overpayment to Deposit Account No. 02-2448 for any additional fees required under 37 C.F.R. § 1.16 or under 37 C.F.R. § 1.17; particularly, extension of time fees.

Respectfully submitted,

BIRCH, STEWART, KOLASCH & BIRCH, LLP

By   
James M. Slattery, #28,380  
P.O. Box 747  
Falls Church, VA 22040-0747  
(703) 205-8000

JMS/rem  
0020-4783P

(Rev. 04/19/2000)

9/PART

09/719138

533 Rec'd PCT/PTO 08 DEC 2000

- 1 -

Specification

HEAT-TRANSFER PIPE WITH INTERNAL GROOVES AND  
MANUFACTURING METHOD AND MANUFACTURING DEVICE

5

THEREFOR

TECHNICAL FIELD

10 The present invention relates to a structure of  
a heat-transfer pipe with internal grooves having grooves  
in an inner surface of a pipe body.

BACKGROUND ART

15 A heat-transfer pipe in a heat exchanger such as  
an evaporator, a condenser or the like for an air  
conditioner is conventionally provided with spiral grooves  
in an inner surface of the pipe from a viewpoint of  
improvement in its heat transfer efficiency as shown in  
Japanese Patent Laid-Open Publication No. Hei 9-42881 so  
that a heat-transfer area is enlarged and an agitation  
20 effect is improved by allowing a refrigerant flowing in the  
pipe to annularly flow.

25 In the case of a heat-transfer pipe in this  
constitution, however, liquid film portions are uniformly  
distributed generally in the pipe when a condensation action  
proceeds to some extent and the thickness gradually

increases. Consequently, heat resistance and diffusion resistance increase and thereby a heat-transfer performance is deteriorated.

5 In order to address this problem, there is a proposal that the inner surface of the pipe is divided into a plurality of areas in the circumferential direction, each having a plurality of rows of grooves arranged in V-shaped patterns, for example, which are symmetric with respect to the direction of a pipe axis and have equal widths in the  
10 circumferential direction, for example, as shown in Japanese Patent Laid-Open Publication No. Hei 9-42880.

In the case of this constitution, the distribution of the refrigerant flowing in the pipe in the pipe circumferential direction can be made ununiform because  
15 of flow merging and dividing actions by the plurality of the grooves arranged in V-shaped patterns provided in the inner surface of the pipe which are symmetric with respect to the pipe axis direction and have equal widths in the circumferential direction as compared with the  
20 aforementioned heat-transfer pipe having the spiral grooves. Since high heat transfer efficiency is achieved in areas where the liquid refrigerant becomes a thin film as a result, the heat transfer efficiency at the time of condensation is improved.

25 However, in the case of the above-described

heat-transfer pipe having grooves arranged in V-shaped patterns in the inner surface of the pipe which are symmetric with respect to the pipe axis direction and have equal widths in the circumferential direction,

5 1. Since refrigerant flows are collided and merged due to the grooves arranged in V-shaped patterns, flow resistance is high. For example, in the case where this heat-transfer pipe is used as an evaporator or the like, sufficient improvement of the heat transfer performance, which is affected by a great pressure loss, can not necessarily be obtained.

10 2. In areas where a refrigerant flow rate is low (areas having little refrigerant circulation), there is little effect even though the refrigerant distribution is made ununiform by the grooves arranged in V-shaped patterns. In the case where the heat-transfer pipe is used as an evaporator, in particular, a heat transfer performance enhancing effect cannot be obtained since a sufficient liquid refrigerant cannot be supplied in the pipe circumferential direction due to the groove structure. That is, improvement of the performance cannot be expected in some use areas.

#### DISCLOSURE OF THE INVENTION

25 An object of the present invention is to provide

a heat-transfer pipe with internal grooves having a heat transfer performance improved as much as possible by reducing a pressure loss and appropriately controlling refrigerant flows in the pipe to be even when a refrigerant flow rate is low, and a manufacturing method thereof as well as a manufacturing device, by which the above-described problems can be solved.

In order to achieve the above object, each aspect of the present invention has the following means for solving the problems.

(I) First aspect of the invention

In a heat-transfer pipe with internal grooves according to the first aspect of the present invention, a plurality of rows of grooves arranged in V-shaped patterns symmetric with respect to a pipe axis direction are provided on an inner surface 2 of a pipe body 1a; and widths of the plurality of rows of the grooves 3 arranged in the V-shaped patterns are made unequal in a circumferential direction.

Thus, when the plurality of rows of the grooves 3 arranged in V-shaped patterns are provided side by side with unequal widths in the circumferential direction, a component of force in the swirling direction are generated in a refrigerant liquid so that the refrigerant liquid flows in an ununiform manner in the pipe axis direction while repeatedly merging and dividing at edges of respective



grooves 3 arranged in the V-shaped patterns. Consequently,  
an annular flow close to the one obtained by combination of  
spiral grooves can be obtained. Further, an agitation  
effect is achieved and thereby a heat transfer performance  
5 is improved.

(II) Second aspect of the invention

In the heat-transfer pipe with internal grooves  
according to the second aspect of the present invention,  
secondary grooves 6 having a prescribed depth are formed  
10 from a top 5a side towards a base 5b side at least in part  
of projected portions 5 formed between respective grooves 3  
of the plurality of rows of the grooves 3 arranged in the V-  
shaped patterns.

Thus, when the secondary grooves 6 having a  
15 prescribed depth are formed from the top part 5a side  
towards the bottom part 5b side at least in part of the  
projected portions 5 formed between the respective grooves 3  
of the plurality of rows of the grooves 3 arranged in V-  
shaped patterns, the flow resistance of the refrigerant  
20 flowing in the pipe is further reduced by the secondary  
grooves 6 and thereby a heat transfer performance is  
effectively improved even when a refrigerant flow rate is  
low.

(III) Third aspect of the invention

25 In the heat-transfer pipe with internal grooves

according to the third aspect of the present invention, the secondary grooves 6 are notched grooves in a spiral direction.

In this case, the flow resistance of the refrigerant flowing in the pipe is effectively reduced by the secondary grooves 6 composed of the notched grooves in the spiral direction. Further, a swirling force is increased in the spiral direction and thereby the heat transfer performance is improved.

(IV) Fourth aspect of the invention

In the heat-transfer pipe with internal grooves according to the fourth aspect of the present invention, secondary grooves 7 having a prescribed depth are formed in an outer surface of at least part of projected portions 5 formed between respective grooves 3 of the rows of grooves 3 arranged in the V-shaped patterns.

Thus, when the secondary grooves 7 having a prescribed depth are formed in outer surfaces at least in part of the projected portions 5 formed between the respective grooves 3 of the rows of grooves arranged in the V-shaped patterns, a pressure loss is reduced since the flow resistance of the refrigerant flowing in the pipe is reduced by the secondary grooves 7 and thereby a heat transfer performance is effectively improved even when a refrigerant flow rate is low.

(V) Fifth aspect of the invention

In the heat-transfer pipe with internal grooves according to the fifth aspect of the present invention, the secondary grooves 7 are fine grooves extending from one side surface of the projected portions 5 to the other side surface thereof.

The flow resistance of the refrigerant flowing in the pipe is effectively reduced by the secondary grooves 7 composed of fine grooves extending from one side surface to the other side surface of the projected portions 5 in this case, and therefore the heat transfer performance is improved. Also, even when the pipe is expanded, both sides of the fine grooves are not crushed and thereby the heat-transfer performance is not deteriorated.

(VI) Sixth aspect of the invention

In a method for manufacturing a heat-transfer pipe with internal grooves according to the sixth aspect of the present invention, a first marking roll 11 for marking a plurality of rows of grooves 3 arranged in V-shaped patterns in a flat plate-like heat-transfer pipe material 13, a second marking roll 12 for marking secondary grooves 7 at least in part of projected portions 5 formed between respective grooves 3 of the plurality of rows of the grooves 3 arranged in the V-shaped patterns and a roll forming device 17 for forming the flat plate-like heat-transfer pipe

material 13 into a cylindrical pipe are used to continuously mark the plurality of rows of the grooves 3 arranged in the V-shaped patterns and the secondary grooves 7 in the flat plate-like heat-transfer pipe material 13 successively by the first and second marking rolls 11, 12 and then form a cylindrical pipe by roll forming by the roll forming device 17.

In this method of manufacturing a heat-transfer pipe with internal grooves, the heat-transfer pipe with internal grooves having the constitutions of the first, fourth and fifth aspects can be easily manufactured only by combining the above-described first and second marking rolls 11, 12 in the direction of the movement of the flat plate-like heat-transfer pipe material 13 to perform continuous markings successively in two stages.

(VII) Seventh aspect of the invention

In a device for manufacturing a heat-transfer pipe with internal grooves according to the seventh aspect of the present invention, a first marking roll 11 for marking a plurality of rows of grooves 3 arranged in V-shaped patterns in a flat plate-like heat-transfer pipe material 13, a second marking roll 12 for marking secondary grooves 7 at least in part of projected portions 5 formed between respective grooves 3 of the plurality of rows of the grooves 3 arranged in V-shaped patterns and a roll forming

device 17 for forming the flat plate-like heat-transfer pipe material 13 into a cylindrical pipe are provided successively side by side in a direction of movement of the flat plate-like heat-transfer pipe material 13 to continuously mark the grooves 3 arranged in the V-shaped patterns and the secondary grooves 7 successively by the first and second marking rolls 11, 12 and then form a cylindrical pipe by roll forming by the roll forming device 17.

By this device for manufacturing the heat-transfer pipe with internal grooves, the heat-transfer pipe with internal grooves having the constitutions of the first, fourth and fifth aspects can be easily manufactured only by combining the above-described first and second marking rolls 11, 12 in the direction of the movement of the flat plate-like heat-transfer pipe material 13 to perform markings successively in two stages.

As a result of the above, according to the heat-transfer pipe with internal grooves and the manufacturing method thereof and the manufacturing device according to each aspect of the present invention, a pressure loss, heat resistance in the heat-transfer pipe and diffusion resistance are reduced even in the case of being constituted as a condenser or an evaporator or even in the case where a refrigerant flow rate is low when the pipe is constituted as

an evaporator. Consequently, a heat exchanger with sufficiently high heat transfer performance can be provided.

#### BRIEF DESCRIPTION OF THE DRAWINGS

5                    Fig. 1 is an enlarged view showing part of a structure in an opened state of a pipe body of a heat-transfer pipe with internal grooves according to a first embodiment of the present invention;

10                   Fig. 2 is an enlarged view of an essential part of the inner surface of the pipe body;

                  Fig. 3 is a perspective view of a cut-off section of the essential part of the inner surface of the pipe body;

15                   Fig. 4 is an enlarged view showing a structure of an essential part of the inner surface of a pipe body of a heat-transfer pipe with internal grooves according to a second embodiment of the present invention;

                  Fig. 5 is an enlarged perspective view of the essential part;

20                   Fig. 6 is a perspective view of a cut-off section of the essential part of the inner surface of the pipe body;

25                   Fig. 7 is an enlarged view showing a structure of an essential part of the inner surface of a pipe body of a heat-transfer pipe with internal grooves according to a

third embodiment of the present invention;

Fig. 8 is an enlarged perspective view of a cut-off section of the essential part; and

Fig. 9 is a perspective view showing manufacture  
5 of a heat-transfer pipe with internal grooves according to the third embodiment of the present invention and a constitution of a manufacturing device.

#### BEST MODE FOR CARRYING OUT THE INVENTION

##### 10 First Embodiment

Figs. 1 to 3 show a structure of a heat-transfer pipe with internal grooves according to a first embodiment of the present invention.

15 First, as shown in Figs. 1 to 3 for example, in the heat-transfer pipe 1 with internal grooves according to this embodiment, first to fifth groups A - E of a plurality of rows of grooves is provided on an inner surface 2 of a pipe body 1a having an electric welded pipe structure. Those groups of grooves are comprised of grooves 3 which are  
20 arranged to be symmetric with respect to a pipe axis direction and to form relatively sharp V-shape patterns, and which are arranged with width of the grooves unequal to each other in the circumferential direction and with a lead angle  $\theta$  of the grooves different from each other, so as to promote  
25 a turbulent flow of a refrigerant liquid flowing in the pipe

body 1a and to promote the refrigerant liquid to become a thin film because coarse and minute refrigerant liquid portions are formed by dividing and merging the refrigerant liquid flow.

5                   In Fig. 3, reference numeral 5 denotes a projected portion formed between the respective grooves 3 arranged in V-shaped patterns. Reference numerals 5a and 5b denote a top and a base of the projected portion, respectively.

10                   Thus, since the first to fifth groups A - E composed of rows of grooves, which are arranged in V-shaped patterns and have a lead angle  $\theta$  different in next groups, are provided side by side with unequal widths in the circumferential direction, the refrigerant liquid flows  
15 ununiformly in the circumferential direction to swirl while repeatedly dividing and merging at edge portions of V-shape patterns of the respective grooves 3. Consequently, the grooves of the present invention can obtain an annular flow close to the one conventionally obtained by combination of  
20 spiral grooves even though the grooves arranged in V-shaped patterns are used. Thus, an effective agitation effect is achieved and thereby a heat transfer performance is improved.

25                   Respective grooves 3 in the first to fifth groups A - E are formed with a prescribed lead angle  $\theta$ , a prescribed depth H and a prescribed number of grooves N so



that the flow resistance of each groove portion is made as small as possible to reduce the pressure loss. Therefore, even when the heat-transfer pipe of the present invention is used for an evaporator at a low refrigerant flow rate, the pressure loss is reduced and thereby the heat transfer performance is improved.

According to the results of experiments conducted by the present inventors, the flow resistance was the smallest and the pressure loss was effectively reduced when the aforementioned lead angle  $\theta$ , groove depth  $H$ , and number of grooves  $N$  are in the range of  $5 - 15^\circ$ ,  $0.2 - 0.3$  mm and  $45 - 55$ , respectively, in the case of a heat-transfer pipe having an outer dimension of  $\phi = 7$  mm.

As described above, according to the constitution of the heat-transfer pipe with internal grooves of this embodiment, widths of groups A - E composed of rows of grooves 3, which are arranged in V-shaped patterns and have a lead angle  $\theta$  different from each other, are set unequal in the circumferential direction rather than equal. Therefore, the refrigerant in the pipe has swirling flow as in the case of the conventional pipe with spiral grooves. Consequently, the heat transfer promotion effect is not deteriorated even when a refrigerant flow rate is low because the refrigerant is effectively supplied in the circumferential direction of the pipe.

The lead angle  $\theta$ , the groove depth  $H$  and the groove number  $N$  of the grooves 3 formed in the V-shaped patterns, the first to fifth groups A - E of which are arranged in the inner surface of the pile, are set to the values by which the smallest flow resistance is obtained corresponding to the aforementioned experiment results. Therefore, since the flow resistance can be made as small as possible to reduce the pressure loss as a result, a heat-transfer pipe for a heat exchanger having a sufficiently high performance can be obtained.

#### Second Embodiment

Figs. 4 to 6 show a structure of a heat-transfer pipe with internal grooves according to a second embodiment of the present invention.

First, in the heat-transfer pipe 1 with internal grooves according to this embodiment, first to fifth groups A - E of a plurality of rows of grooves is provided on an inner surface 2 of a pipe body 1a having the same electric welded pipe structure as described above. Those groups of grooves are comprised of grooves 3 which are arranged to be symmetric with respect to a pipe axis direction and to form relatively sharp V-shape patterns, and which are arranged with width of the grooves unequal to each other in the circumferential direction and with a lead angle  $\theta$  of the grooves different from each other, so as to promote a

turbulent flow of a refrigerant liquid flowing in the pipe body 1a and to promote the refrigerant liquid to become a thin film because coarse and minute refrigerant liquid portions are formed by dividing and merging the refrigerant liquid flow.

In Figs. 5 and 6, reference numeral 5 denotes a projected portion formed between the respective grooves 3 arranged in V-shaped patterns. Reference numerals 5a and 5b denote a top and a base of the projected portion 5, respectively. In this embodiment, secondary grooves 6 are provided and the secondary grooves 6 are composed of notched grooves (chipped grooves) in the spiral direction with a prescribed depth d from the top 5a towards the base 5b. Consequently, the flow resistance of the refrigerant is reduced and the refrigerant is further urged in the swirling direction.

Thus, since the first to fifth groups A - E composed of rows of grooves, which are arranged in V-shaped patterns and have a lead angle  $\theta$  different in next groups, are provided side by side with unequal widths in the circumferential direction, the refrigerant liquid flows ununiformly in the circumferential direction to swirl while repeatedly dividing and merging at edge portions of V-shape patterns of the respective grooves 3. Consequently, the grooves of the present invention can obtain an annular flow

close to the one conventionally obtained by combination of spiral grooves even though the grooves arranged in V-shaped patterns are used. Thus, an effective agitation effect is achieved and thereby a heat transfer performance is improved.

5                   Respective grooves 3 in the first to fifth groups A - E are formed with the secondary grooves 6 composed of notched grooves (chipped grooves) in the spiral direction as described above as well as a prescribed lead angle  $\theta$ , a prescribed depth H and a prescribed number of  
10                   grooves as in the first embodiment, so that the flow resistance of each groove portion is made as small as possible to reduce the pressure loss. Therefore, even when the heat-transfer pipe of the present invention is used for an evaporator at a low refrigerant flow rate, the pressure  
15                   loss is reduced and thereby the heat transfer performance is improved.

                  According to the results of experiments conducted by the present inventors as described above, the flow resistance was the smallest and the pressure loss was  
20                   effectively reduced when the aforementioned lead angle  $\theta$ , groove depth H, and number of grooves N are in the range of 5 - 15°, 0.2 - 0.3 mm and 45 - 55, respectively, in the case of a heat-transfer pipe having an outer dimension of  $\phi = 7$  mm.

25                   As described above, according to the

constitution of the heat-transfer pipe with internal grooves of this embodiment, widths of groups A - E composed of rows of grooves 3, which are arranged in V-shaped patterns and have a lead angle  $\theta$  different from each other, are set  
5 unequal in the circumferential direction. Therefore, the refrigerant in the pipe has swirling flow as in the case of the conventional pipe with spiral grooves. Consequently, the heat transfer promotion effect is not deteriorated even when a refrigerant flow rate is low because the refrigerant  
10 is effectively supplied in the circumferential direction of the pipe.

The lead angle  $\theta$ , the groove depth H and the groove number N of the grooves 3 formed in the V-shaped patterns, the first to fifth groups A - E of which are  
15 arranged in the inner surface of the pipe, are set to the values by which the smallest flow resistance is obtained. In addition, the secondary grooves 6 are formed in the projected portions 5 provided between the respective grooves 3 as main grooves in V-shaped patterns and the secondary  
20 grooves 6 are notched grooves from the top 5a towards the base 5b of the projected portions 5 and are directed in the spiral direction. Therefore, since the flow resistance can be made as small as possible to reduce the pressure loss and swirling force in the spiral direction can be further  
25 increased, a heat-transfer pipe for a heat exchanger having

a still higher performance can be obtained.

### Third Embodiment

5 Figs. 7 to 9 show a structure of a heat-transfer pipe with internal grooves according to a third embodiment of the present invention and a constitution of a manufacturing device employing a method for manufacturing the heat-transfer pipe, respectively.

10 First, in the heat-transfer pipe 1 with internal grooves according to this embodiment, first to fifth groups A - E of a plurality of rows of grooves is provided on an inner surface 2 of a pipe body 1a having the same electric welded pipe structure as described above. Those groups of grooves are comprised of grooves 3 which are arranged to be symmetric with respect to a pipe axis direction and to form  
15 relatively sharp V-shape patterns, and which are arranged with width of the grooves unequal to each other in the circumferential direction and with a lead angle  $\theta$  of the grooves different from each other, so as to promote a turbulent flow of a refrigerant liquid flowing in the pipe  
20 body 1a and to promote the refrigerant liquid to become a thin film because coarse and minute refrigerant liquid portions are formed by dividing and merging the refrigerant liquid flow.

25 In Figs. 7 and 8, reference numeral 5 denotes a projected portion formed between the respective grooves 3

arranged in V-shaped patterns. Reference numerals 5a and 5b denote a top and a base of the projected portion 5, respectively. In this embodiment, secondary grooves 7 composed of fine grooves having a prescribed depth are formed from one side of an outer surface of the projected portion 5 to the other side thereof to direct toward, for example, the spiral direction. Consequently, the flow resistance of the refrigerant is reduced and the refrigerant is further urged in the swirling direction.

Thus, since the first to fifth groups A - E composed of rows of grooves, which are arranged in V-shaped patterns and have a lead angle  $\theta$  different in next groups, are provided side by side with unequal widths in the circumferential direction, the refrigerant liquid flows ununiformly in the circumferential direction to swirl while repeatedly dividing and merging at edge portions of V-shape patterns of the respective grooves 3. Consequently, the grooves of the present invention can obtain an annular flow close to the one conventionally obtained by combination of spiral grooves even though the grooves arranged in V-shaped patterns are used. Thus, an effective agitation effect is achieved and thereby a heat transfer performance is improved.

Respective grooves 3 in the first to fifth groups A - E are formed with the secondary fine grooves 7 formed from one side of an outer surface of the projected

portion 5 to the other side thereof in a prescribed depth to direct toward the spiral direction as well as with a prescribed lead angle  $\theta$ , a prescribed depth H and a prescribed number of grooves as in the first embodiment.

5 Consequently, the flow resistance of each groove portion is made as small as possible to reduce the pressure loss. Therefore, even when the heat-transfer pipe of the present invention is used for an evaporator at a low refrigerant flow rate, the pressure loss is reduced and thereby the heat  
10 transfer performance is improved. Also, even when the pipe is expanded, the fine grooves on the side portions are not crushed and thereby the heat transfer performance is not deteriorated.

According to the results of experiments  
15 conducted by the present inventors as described above, the flow resistance was the smallest and the pressure loss was effectively reduced when the aforementioned lead angle  $\theta$ , groove depth H, and number of grooves N are in the range of 5 - 15°, 0.2 - 0.3 mm and 45 - 55, respectively, in the case  
20 of a heat-transfer pipe having an outer dimension of  $\phi = 7$  mm.

As described above, according to the constitution of the heat-transfer pipe with internal grooves of this embodiment, widths of groups A - E composed of rows  
25 of grooves 3, which are arranged in V-shaped patterns and



have a lead angle  $\theta$  different from each other, are set unequal. Therefore, the refrigerant in the pipe has swirling flow as in the case of the conventional pipe with spiral grooves. Consequently, the heat transfer promotion effect is not deteriorated even when a refrigerant flow rate is low because the refrigerant is effectively supplied in the circumferential direction of the pipe.

The lead angle  $\theta$ , the groove depth  $H$  and the groove number  $N$  of the grooves 3 formed in the V-shaped patterns, the first to fifth groups A - E of which are arranged in the inner surface of the pile, are set to the values by which the smallest flow resistance is obtained. In addition, the secondary grooves 7 composed of fine grooves are formed from one side of an outer surface of the projected portion 5 to the other side thereof to direct toward, for example, the spiral direction. Therefore, since the flow resistance can be made as small as possible to reduce the pressure loss and swirling force in the spiral direction can be further increased, a heat-transfer pipe for a heat exchanger having a still higher performance can be obtained. Also, even when the pipe is expanded, the fine grooves on the side portions are not crushed and thereby the heat transfer performance is not deteriorated.

The heat-transfer pipe with internal grooves

having the groups A - E of rows of the grooves arranged in V-shaped patterns and secondary grooves 7 described above are easily manufactured by the following method by using, for example, a manufacturing device shown in Fig. 9.

5           In Fig. 9, reference numeral 11 denotes a first marking roll which has a marking processing surface 11a corresponding to the first to fifth groups A - E of rows of grooves arranged as main grooves in V-shaped patterns. Reference numeral 12 denotes a second marking roll which has  
10   a marking processing surface 12a for marking the fine grooves 7 provided to extend, for example, in the spiral direction from one side to the other side of an outer surface of the projected portion 5 formed between the grooves 3 arranged in V-shaped patterns in the first to  
15   fifth groups A - E. Reference numeral 13 denotes a flat plate-like heat-transfer pipe material. Reference numeral 16 denotes a heating device for heating and softening the heat-transfer pipe material at the time of roll forming. Reference numeral 14 denotes a first pressure roller for  
20   sandwiching and pressing the flat plate-like heat-transfer pipe material 13 with the aforementioned first marking roll 11. Reference numeral 15 denotes a second pressure roller for sandwiching and pressing the flat plate-like heat-transfer pipe material 13 with the aforementioned second  
25   marking roll 12. Reference numeral 17 denotes a roll

forming device having a roll forming hole 17a for roll-forming into a cylindrical shape the heat-transfer pipe material 13 which has the first to fifth groups A - E of rows of grooves arranged in V-shaped patterns and the secondary grooves 7 formed thereon via the first and second marking rollers 11, 12 and is heated and softened by the heating device 16. The first marking roll 11 and the first pressure roller 14, the second marking roll 12 and the second pressure roller 15, the heating device 16 and the roll forming device 17 are successively provided side by side at predetermined intervals in the movement direction (see the arrow) of the heat-transfer pipe material 13.

Therefore, in the device for manufacturing the heat-transfer pipe with internal grooves, the first marking roll 11 and the first pressure roller 14 are used for marking the first to fifth groups A - E of rows of grooves arranged in V-shaped patterns, the second marking roll 12 and the second pressure roller 15 are used for marking the secondary grooves 7 in part of the projected portions formed between the respective grooves 3 of the first to fifth groups A - E of rows of grooves arranged in V-shaped patterns, and the heating device 16 and the roll forming device 17 are used for forming the flat plate-like heat-transfer pipe material 13 into a cylindrical pipe. The first and second marking rolls 11, 12 are rotatably operated

so that the respective grooves 3 of the first to fifth groups A - E and the secondary grooves 7 are successively marked in two stages on the flat plate-like heat-transfer pipe material 13, and then the heat-transfer pipe material  
5 13 can be heated and softened by the heating device 16 and then roll-formed by the roll forming device 17 to form a cylindrical pipe.

That is, in the method and device for manufacturing the heat-transfer pipe with internal grooves,  
10 the heat-transfer pipe with internal grooves having a constitution shown in Figs. 7 and 8 can be easily manufactured only by two stage successive marking of the grooves with the above-described first and second marking rolls 11, 12 combined in the direction of the movement of  
15 the flat plate-like heat-transfer pipe material 13.

#### Other Embodiments

Although a heat-transfer pipe of a electric welded pipe type is described as an example in the above embodiments, it is needless to say that the internal groove  
20 structures of the above embodiments can be also applied to a seam welded type of heat-transfer pipe.

#### INDUSTRIAL APPLICABILITY

As described above, the heat-transfer pipe with  
25 internal grooves and the manufacturing method thereof and



CLAIMS:

1. A heat-transfer pipe with internal grooves,  
wherein

5 a plurality of rows of grooves arranged in V-  
shaped patterns (3) symmetric with respect to a pipe axis  
direction are provided on an inner surface (2) of a pipe  
body (1a); and

10 widths of the plurality of rows of the grooves  
(3) arranged in the V-shaped patterns are made unequal in a  
circumferential direction.

2. The heat-transfer pipe with internal grooves  
according to claim 1, wherein

15 secondary grooves (6) having a prescribed depth  
are formed from a top (5a) side towards a base (5b) side at  
least in part of projected portions (5) formed between  
respective grooves (3) of the plurality of rows of the  
grooves (3) arranged in the V-shaped patterns.

3. The heat-transfer pipe with internal grooves  
according to claim 2, wherein

20 the secondary grooves (6) are notched grooves in  
a spiral direction.

4. The heat-transfer pipe with internal grooves  
according to claim 1, wherein

25 secondary grooves (7) having a prescribed depth  
are formed in an outer surface of at least part of projected

portions (5) formed between respective grooves (3) of the rows of grooves (3) arranged in the V-shaped patterns.

5. The heat-transfer pipe with internal grooves according to claim 4, wherein

5 the secondary grooves (7) are fine grooves extending from one side surface of the projected portions (5) to the other side surface thereof.

6. A method for manufacturing a heat-transfer pipe with internal grooves, wherein

10 a first marking roll (11) for marking a plurality of rows of grooves (3) arranged in V-shaped patterns in a flat plate-like heat-transfer pipe material (13), a second marking roll (12) for marking secondary grooves (7) at least in part of projected portions (5)

15 formed between respective grooves (3) of the plurality of rows of the grooves (3) arranged in the V-shaped patterns and a roll forming device (17) for forming the flat plate-like heat-transfer pipe material (13) into a cylindrical pipe are used to continuously mark the plurality of rows of

20 the grooves (3) arranged in the V-shaped patterns and the secondary grooves (7) in the flat plate-like heat-transfer pipe material (13) successively by the first and second marking rolls (11), (12) and then form a cylindrical pipe by roll forming by the roll forming device (17).

25 7. A device for manufacturing a heat-transfer pipe

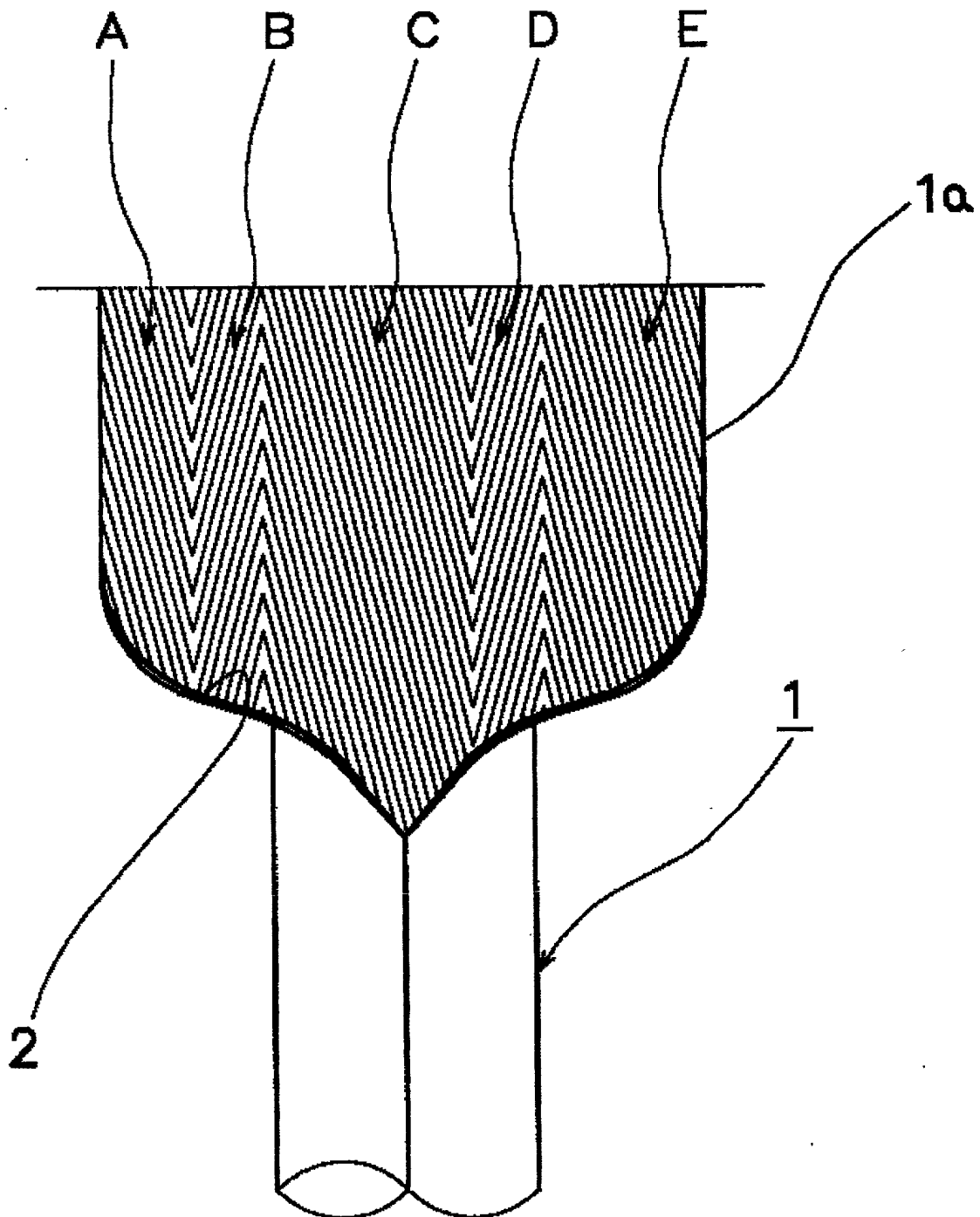
with internal grooves, wherein

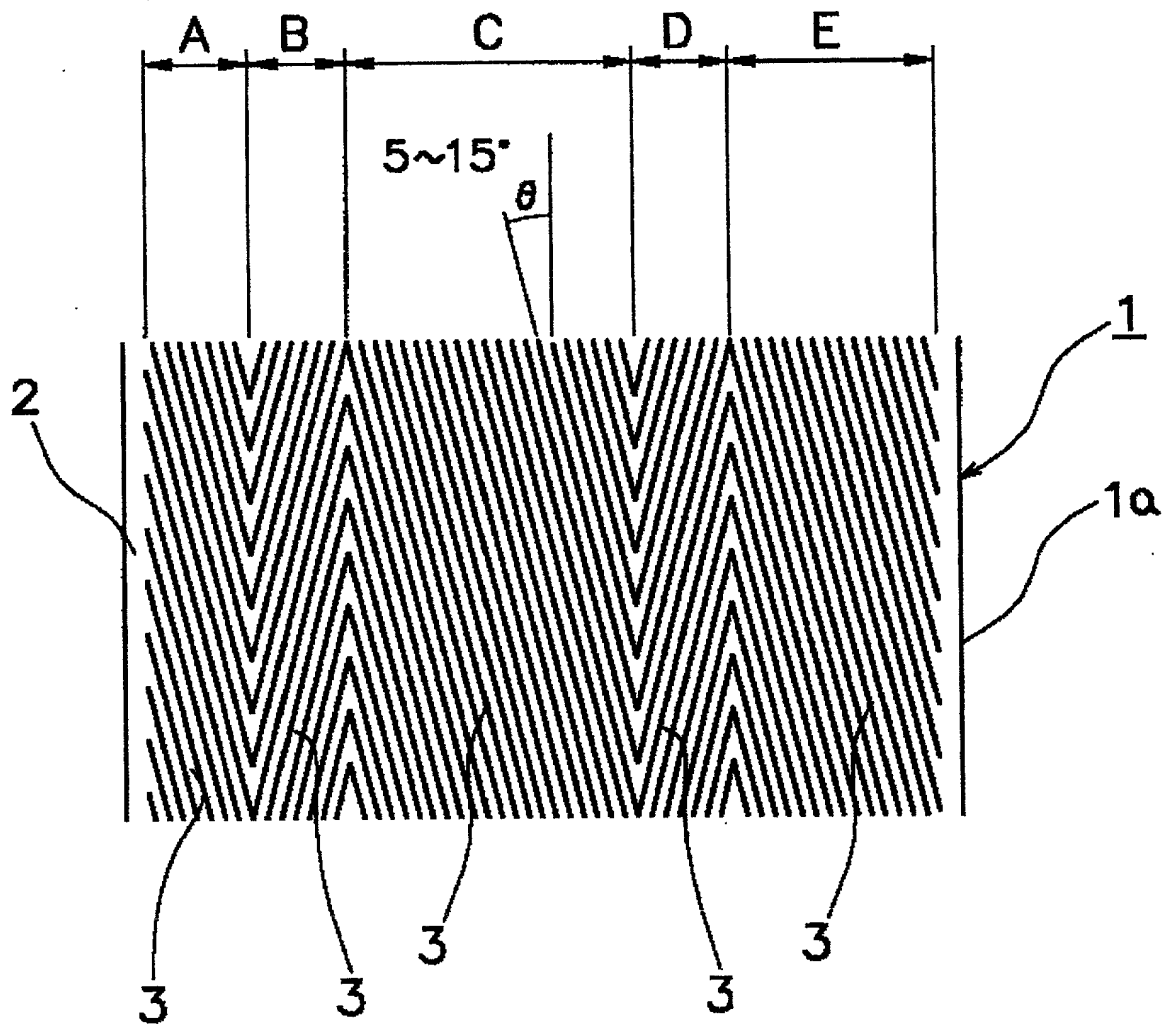
5 a first marking roll (11) for marking a plurality of rows of grooves (3) arranged in V-shaped patterns in a flat plate-like heat-transfer pipe material (13), a second marking roll (12) for marking secondary grooves (7) at least in part of projected portions (5) formed between respective grooves (3) of the plurality of rows of the grooves (3) arranged in V-shaped patterns and a roll forming device (17) for forming the flat plate-like heat-transfer pipe material (13) into a cylindrical pipe are provided successively side by side in a direction of movement of the flat plate-like heat-transfer pipe material (13) to continuously mark the grooves (3) arranged in the V-shaped patterns and the secondary grooves (7) successively by the first and second marking rolls (11), (12) and then form a cylindrical pipe by roll forming by the roll forming device (17).



ABSTRACT

A pressure loss is reduced by providing a plurality of rows of grooves (3) arranged in V-shaped patterns on an inner surface of a pipe body (1a) so as for the rows of grooves to be symmetric with respect to the pipe axis direction and by forming secondary grooves (6), (7) in a prescribed depth in part of projected portions (5) formed therebetween. Also, even when a refrigerant flow rate is low, the refrigerant flow in the pipe can be appropriately controlled by making widths of the plurality of rows of the grooves (3) arranged in the V-shaped patterns unequal in the circumferential direction to generate swirl in the spiral direction and thereby a heat transfer performance is improved as much as possible.

*Fig. 1*

*Fig. 2*

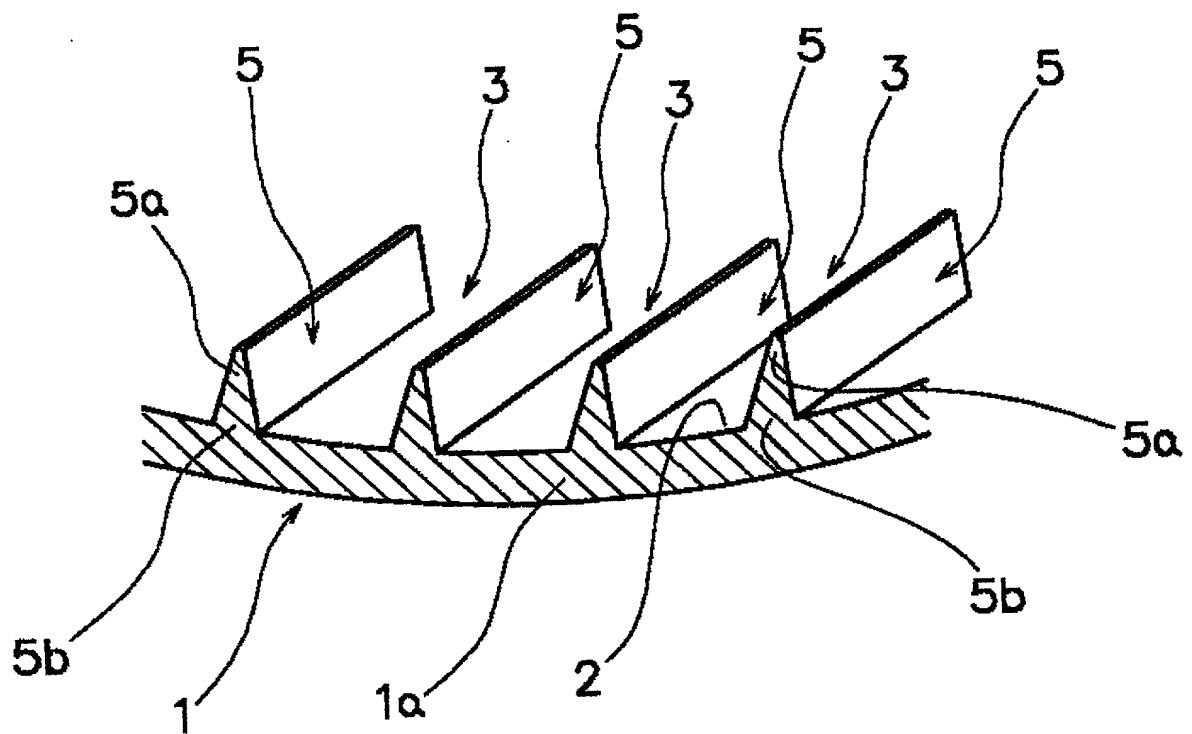
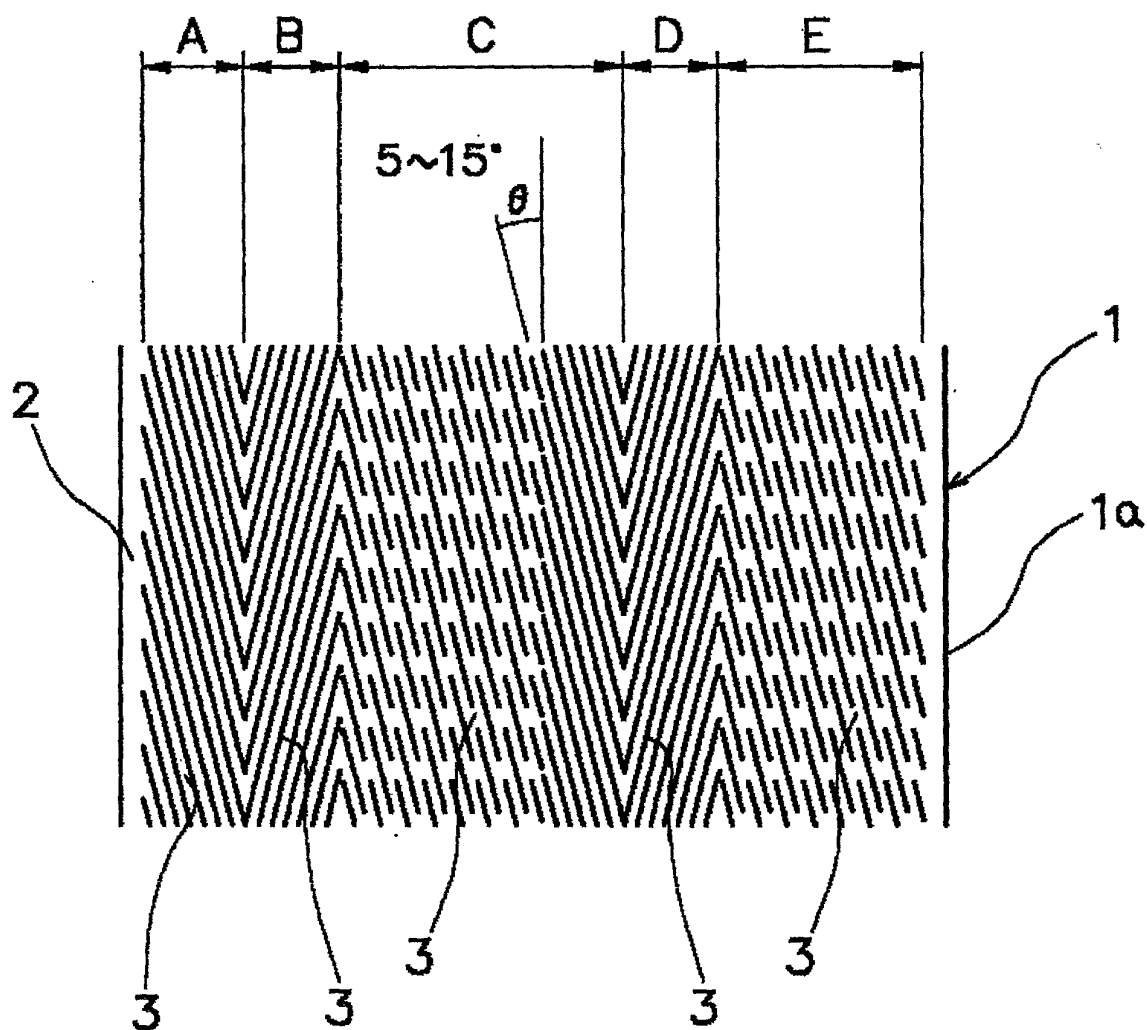
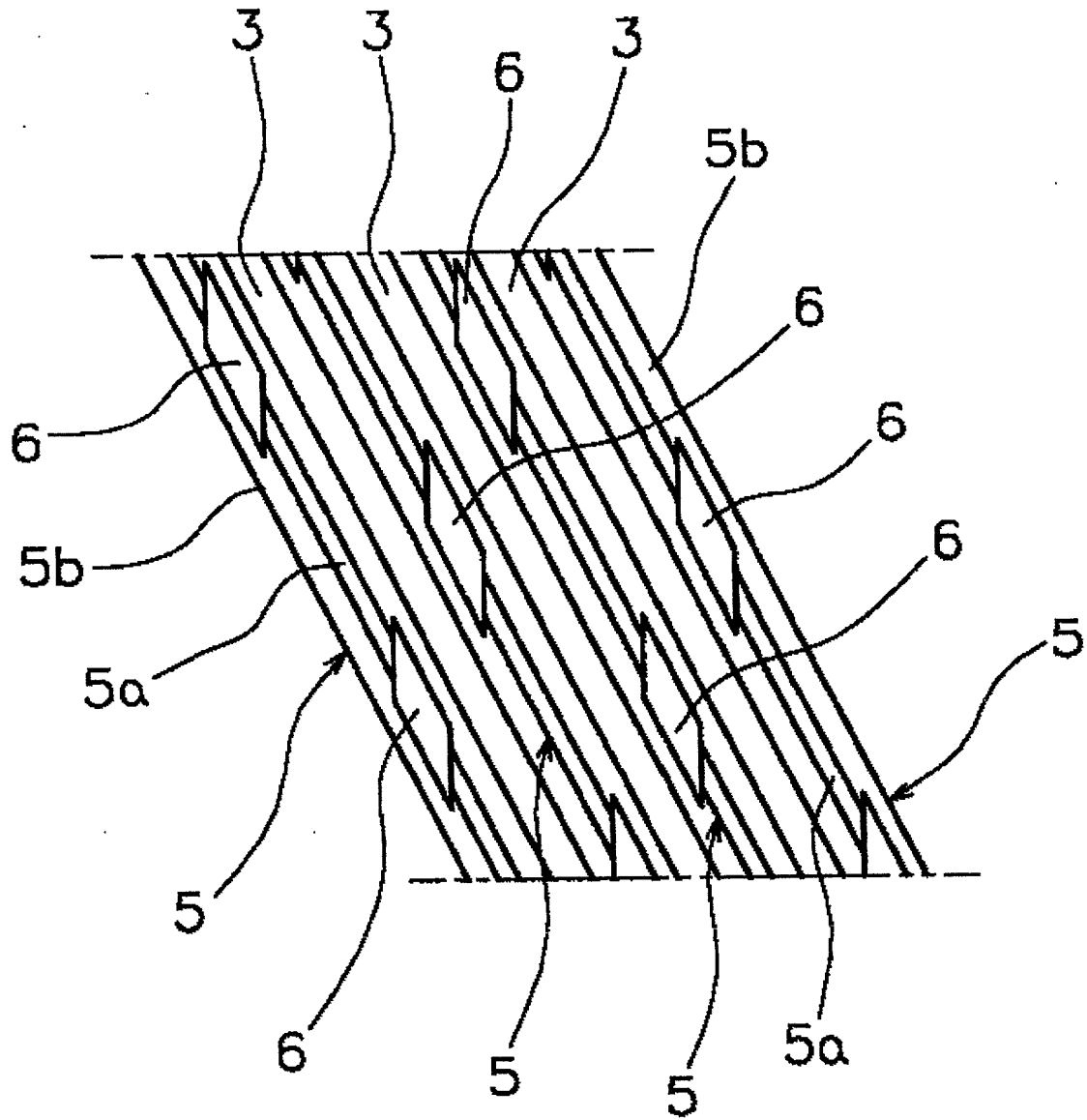
*Fig. 3*

Fig. 4



*Fig. 5*

**Fig. 6**

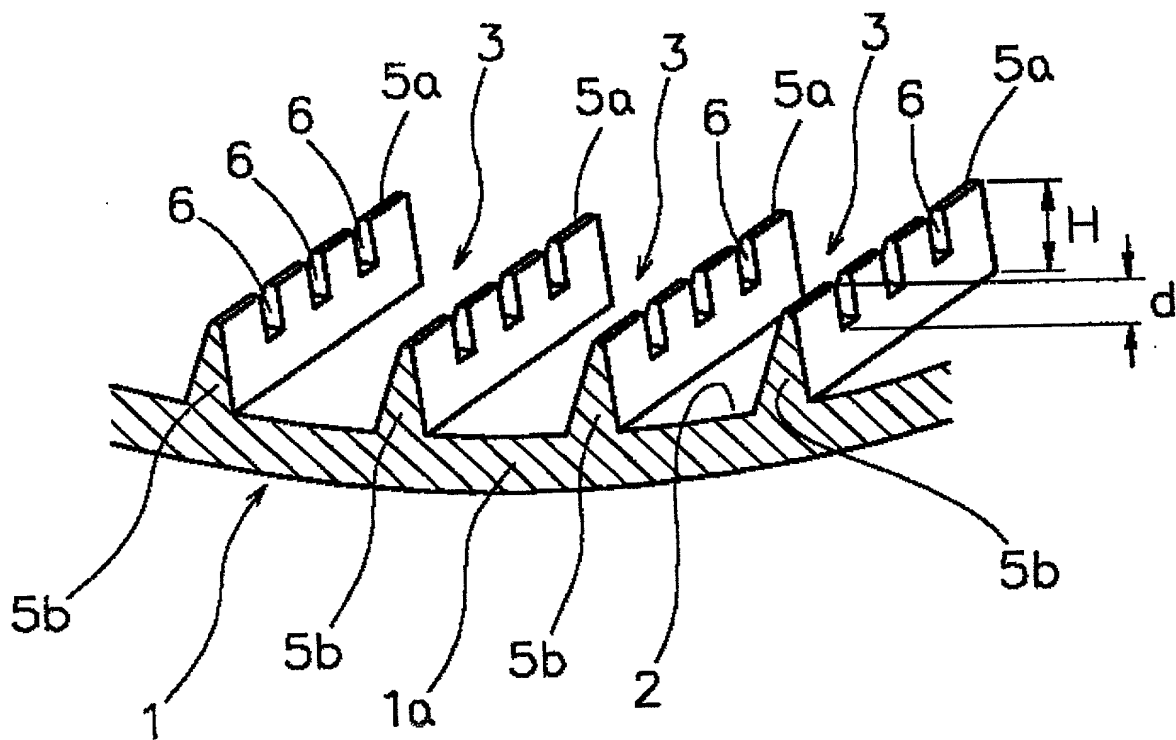
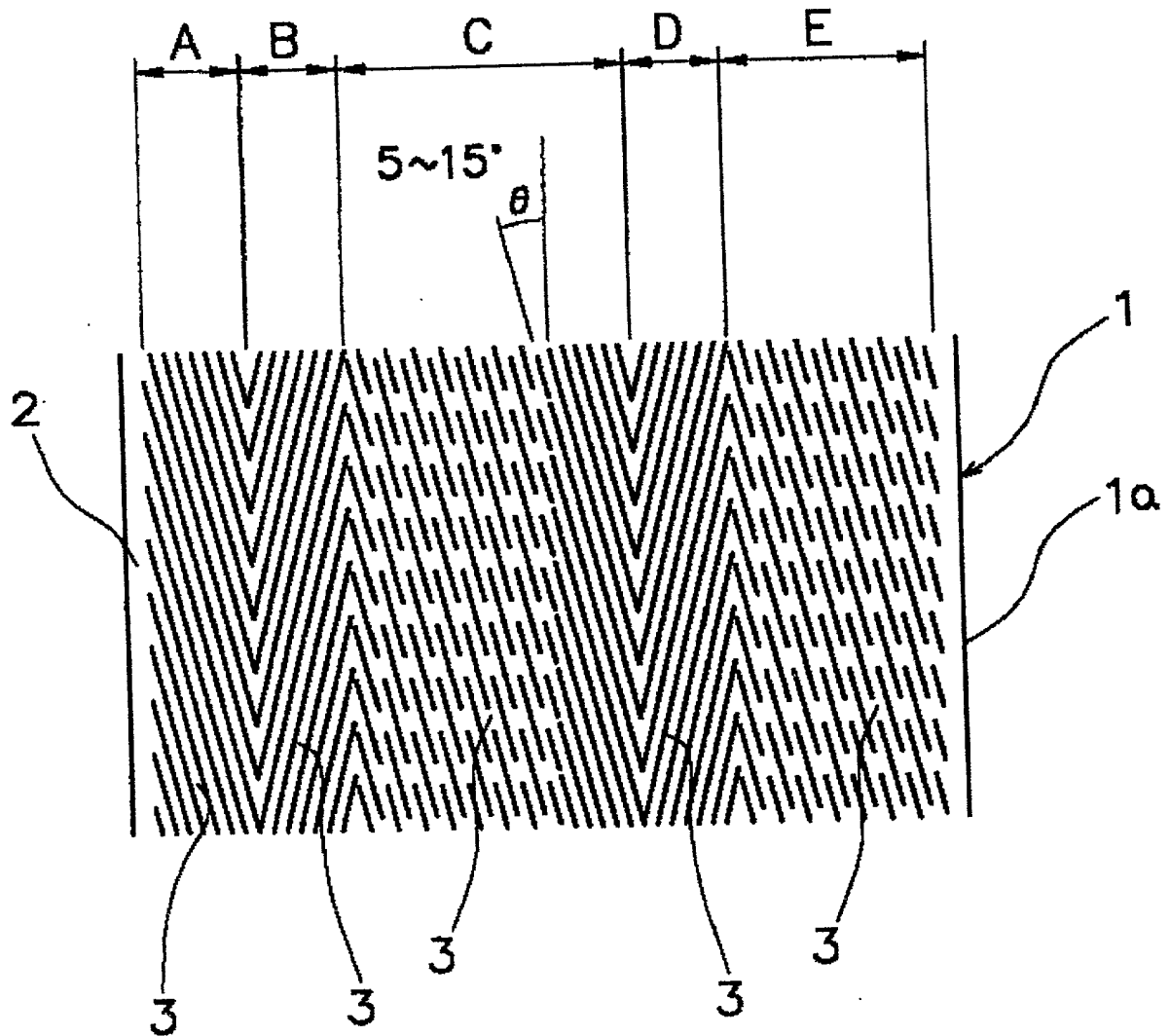


Fig. 7





**Fig. 8**

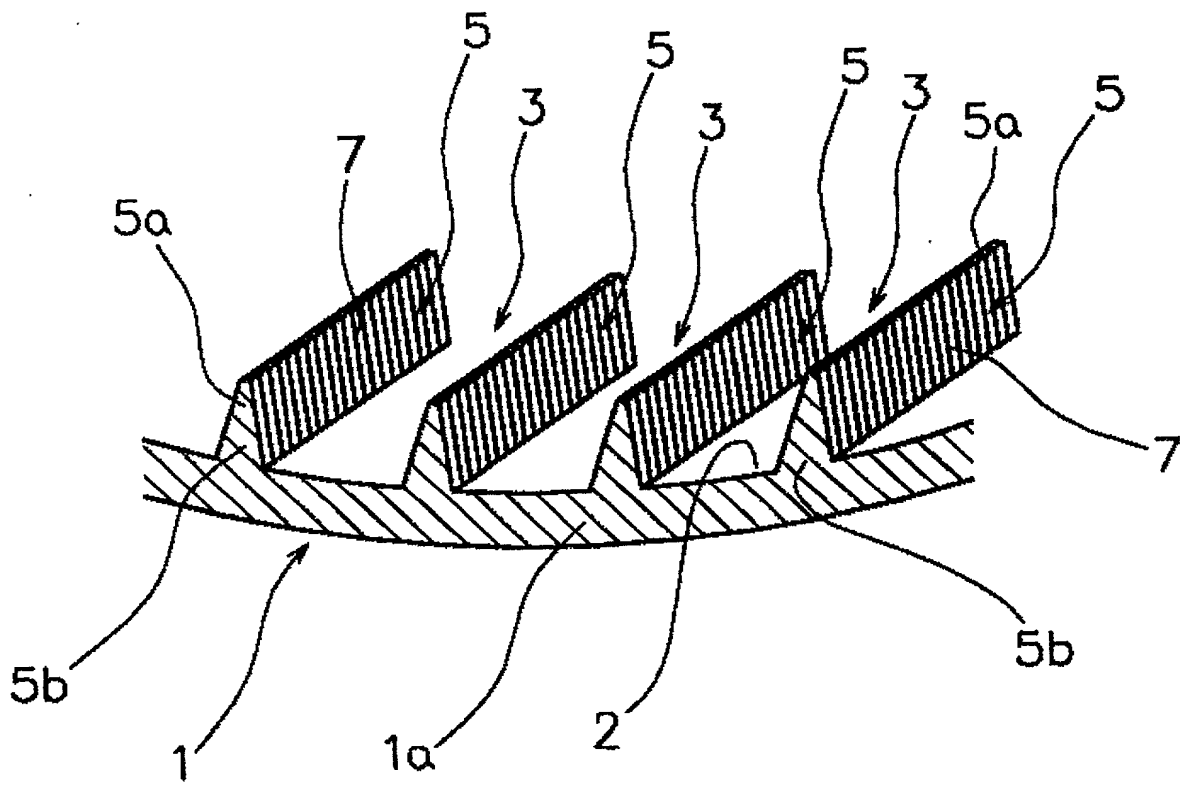
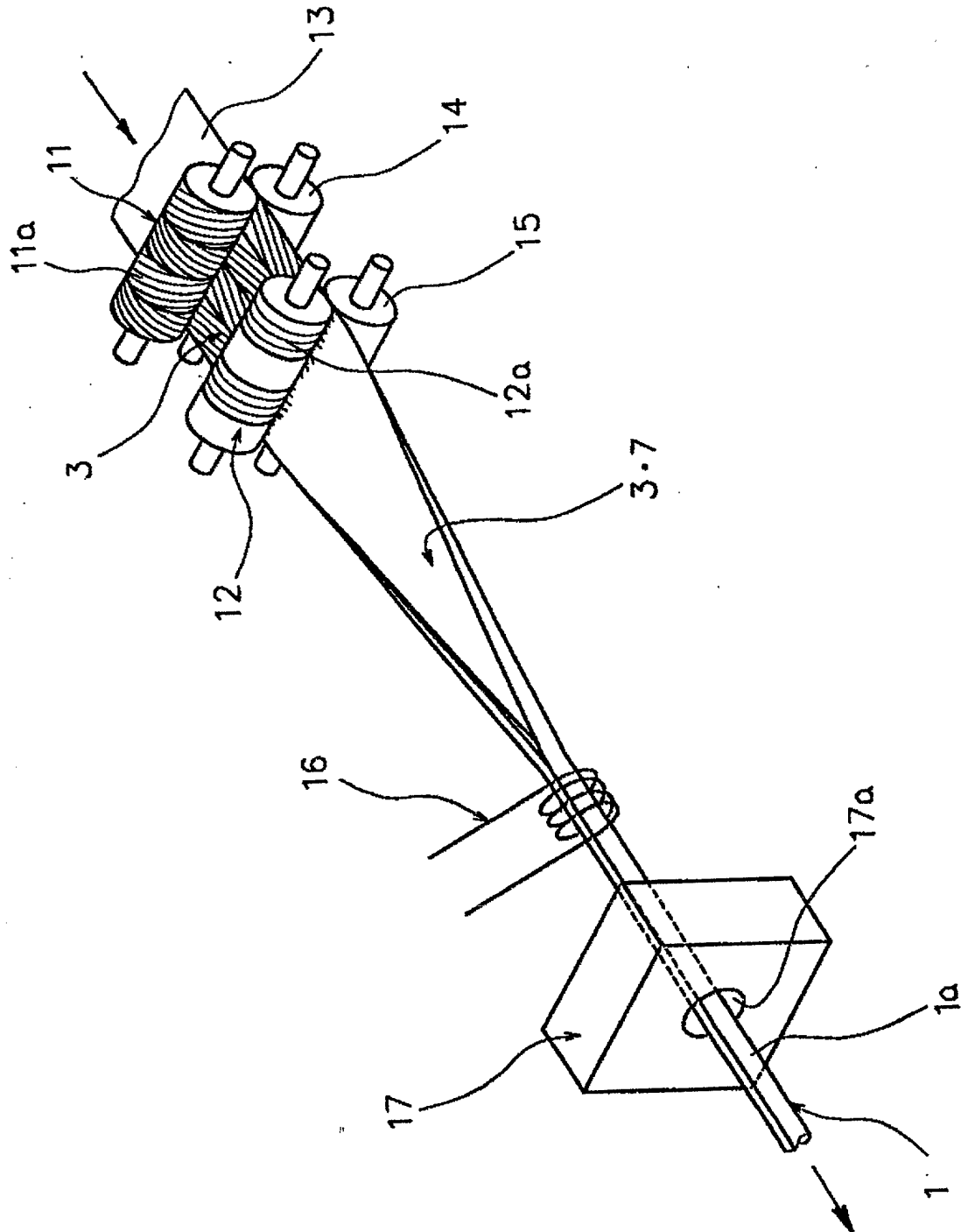


Fig. 9



PLEASE NOTE:  
YOU MUST  
COMPLETE THE  
FOLLOWING: ↓COMBINED DECLARATION AND POWER OF ATTORNEY  
FOR PATENT AND DESIGN APPLICATIONS

As a below named inventor, I hereby declare that: my residence, post office address and citizenship are as stated next to my name; that I verily believe that I am the original, first and sole inventor (if only one inventor is named below) or an original, first and joint inventor (if plural inventors are named below) of the subject matter which is claimed and for which a patent is sought on the invention entitled:

Insert Title: → HEAT-TRANSFER PIPE WITH INTERNAL GROOVES AND MANUFACTURING  
METHOD AND MANUFACTURING DEVICE THEREFOR

Fill in Appropriate  
Information —  
For Use →  
Without  
Specification  
Attached:

the specification of which is attached hereto. If not attached hereto,

the specification was filed on \_\_\_\_\_ as  
United States Application Number \_\_\_\_\_;  
and amended on \_\_\_\_\_ (if applicable); and/or  
the specification was filed on April 10, 2000 as PCT  
International Application Number PCT/JP00/02300; and was  
amended under PCT Article 19 on \_\_\_\_\_ (if applicable)

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is material to patentability as defined in Title 37, Code of Federal Regulations, §1.56.

I do not know and do not believe the same was ever known or used in the United States of America before my or our invention thereof, or patented or described in any printed publication in any country before my or our invention thereof or more than one year prior to this application, that the same was not in public use or on sale in the United States of America more than one year prior to this application, that the invention has not been patented or made the subject of an inventor's certificate issued before the date of this application in any country foreign to the United States of America on an application filed by me or my legal representatives or assigns more than twelve months (six months for designs) prior to this application, and that no application for patent or inventor's certificate on this invention has been filed in any country foreign to the United States of America prior to this application by me or my legal representatives or assigns, except as follows.

I hereby claim foreign priority benefits under Title 35, United States Code, §119 (a)-(d) of any foreign application(s) for patent or inventor's certificate listed below and have also identified below any foreign application for patent or inventor's certificate having a filing date before that of the application on which priority is claimed:

## Prior Foreign Application(s)

## Priority Claimed

Insert Priority  
Information: →  
(if appropriate)

<u>11-100767</u> (Number)	<u>Japan</u> (Country)	<u>04/08/1999</u> (Month / Day / Year Filed)	<input checked="" type="checkbox"/> Yes <input type="checkbox"/> No	<input type="checkbox"/> Yes <input type="checkbox"/> No
_____ (Number)	_____ (Country)	_____ (Month / Day / Year Filed)	<input type="checkbox"/> Yes <input type="checkbox"/> No	<input type="checkbox"/> Yes <input type="checkbox"/> No
_____ (Number)	_____ (Country)	_____ (Month / Day / Year Filed)	<input type="checkbox"/> Yes <input type="checkbox"/> No	<input type="checkbox"/> Yes <input type="checkbox"/> No
_____ (Number)	_____ (Country)	_____ (Month / Day / Year Filed)	<input type="checkbox"/> Yes <input type="checkbox"/> No	<input type="checkbox"/> Yes <input type="checkbox"/> No

I hereby claim the benefit under Title 35, United States Code, §119(e) of any United States provisional application(s) listed below.

Insert Provisional  
Application(s): →  
(if any)

_____ (Application Number)	_____ (Filing Date)
_____ (Application Number)	_____ (Filing Date)

All Foreign Applications, if any, for any Patent or Inventor's Certificate Filed More than 12 Months (6 Months for Designs) Prior to the Filing Date of This Application:

Insert Requested  
Information: →  
(if appropriate)

Country	Application Number	Date of Filing (Month / Day / Year)
_____	_____	_____
_____	_____	_____

I hereby claim the benefit under Title 35, United States Code, §120 of any United States and/or PCT application(s) listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States and/or PCT application in the manner provided by the first paragraph of Title 35, United States Code, §112, I acknowledge the duty to disclose information which is material to patentability as defined in Title 37, Code of Federal Regulations, §1.56 which became available between the filing date of the prior application and the national or PCT international filing date of this application:

Insert Prior U.S.  
Application(s): →  
(if any)

_____ (Application Number)	_____ (Filing Date)	_____ (Status — patented, pending, abandoned)
_____ (Application Number)	_____ (Filing Date)	_____ (Status — patented, pending, abandoned)

I hereby appoint the following attorneys to prosecute this application and/or an international application based on this application and to transact all business in the Patent and Trademark Office connected therewith and in connection with the resulting patent based on instructions received from the entity who first sent the application papers to the attorneys identified below, unless the inventor(s) or assignee provides said attorneys with a written notice to the contrary:

Raymond C. Stewart	(Reg. No. 21,066)	Terrell C. Birch	(Reg. No. 19,382)
Joseph A. Kolasch	(Reg. No. 22,463)	James M. Slattery	(Reg. No. 28,380)
Bernard L. Sweeney	(Reg. No. 24,448)	Michael K. Mutter	(Reg. No. 29,680)
Charles Gorenstein	(Reg. No. 29,274)	Gerald M. Murphy, Jr.	(Reg. No. 28,977)
Leonard R. Svensson	(Reg. No. 30,330)	Terry L. Clark	(Reg. No. 32,644)
Andrew D. Meikle	(Reg. No. 32,868)	Marc S. Weiner	(Reg. No. 32,181)
Joe McKinney Muncy	(Reg. No. 32,334)	C. Joseph Faraci	(Reg. No. 32,350)
Donald J. Daley	(Reg. No. 34,313)	John W. Bailey	(Reg. No. 32,881)
John A. Castellano	(Reg. No. 35,094)		

Send Correspondence to: **BIRCH, STEWART, KOLASCH & BIRCH, LLP**  
P.O. Box 747 • Falls Church, Virginia 22040-0747  
Telephone: (703) 205-8000 • Facsimile: (703) 205-8050

**PLEASE NOTE:  
YOU MUST  
COMPLETE  
THE  
FOLLOWING:**

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Full Name of First or Sole Inventor: Insert Name of Inventor Insert Date This Document is Signed	GIVEN NAME	FAMILY NAME	INVENTOR'S SIGNATURE	DATE*
	Hirokazu	FUJINO	Hirokazu FUJINO	01/09/2001
Insert Residence	Residence (City, State & Country)			CITIZENSHIP
Insert Citizenship	Sakai-shi, Osaka, Japan SPX			Japan
Insert Post Office Address	POST OFFICE ADDRESS (Complete Street Address including City, State & Country) c/o Kanaoka-kojo, Sakai-seisakusho of DAIKIN INDUSTRIES, LTD., 1304, Kanaoka-cho, Sakai-shi, Osaka 591-8022, Japan			
Full Name of Second Inventor, if any	GIVEN NAME	FAMILY NAME	INVENTOR'S SIGNATURE	DATE*
	Kazushige	KASAI	Kazushige KASAI	01/09/2001
Full Name of Third Inventor, if any	GIVEN NAME	FAMILY NAME	INVENTOR'S SIGNATURE	DATE*
	Kanji	AKAI	Kanji AKAI	01/12/2001
Full Name of Fourth Inventor, if any	GIVEN NAME	FAMILY NAME	INVENTOR'S SIGNATURE	DATE*
	Noriaki	OKAMOTO	Noriaki OKAMOTO	01/12/2001
Full Name of Fifth Inventor, if any	GIVEN NAME	FAMILY NAME	INVENTOR'S SIGNATURE	DATE*
	Masaru	UCHIMITSU	Masaru UCHIMITSU	01/12/2001
POST OFFICE ADDRESS (Complete Street Address including City, State & Country) c/o Kanaoka-kojo, Sakai-seisakusho of DAIKIN INDUSTRIES, LTD., 1304, Kanaoka-cho, Sakai-shi, Osaka 591-8022, Japan				



(51) 国際特許分類7 F28F 1/40, B21D 5/12	A1	(11) 国際公開番号 WO00/62001  (43) 国際公開日 2000年10月19日(19.10.00)
(21) 国際出願番号 PCT/JP00/02300  (22) 国際出願日 2000年4月10日(10.04.00)  (30) 優先権データ 特願平11/100767 1999年4月8日(08.04.99) JP  (71) 出願人 (米国を除くすべての指定国について) ダイキン工業株式会社 (DAIKIN INDUSTRIES, LTD.) [JP/JP] 〒530-8323 大阪府大阪市北区中崎西2丁目4番12号 梅田センタービル Osaka, (JP) (72) 発明者 ; および (75) 発明者 / 出願人 (米国についてののみ) 藤野宏和(FUJINO, Hirokazu) [JP/JP] 笠井一成(KASAI, Kazushige) [JP/JP] 赤井寛二(AKAI, Kanji) [JP/JP] 岡本哲彰(OKAMOTO, Noriaki) [JP/JP] 内満 優(UCHIMITSU, Masaru) [JP/JP] 〒591-8022 大阪府堺市金岡町1304番地 ダイキン工業株式会社 堺製作所 金岡工場内 Osaka, (JP)		(74) 代理人 青山 葆, 外(AOYAMA, Tamotsu et al.) 〒540-0001 大阪府大阪市中央区城見1丁目3番7号 IMPビル 青山特許事務所 Osaka, (JP)  (81) 指定国 AU, CN, SG, US, 欧州特許 (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE)  添付公開書類 国際調査報告書
(54) Title: <u>HEAT TRANSFER TUBE WITH INTERNAL GROOVES AND METHOD AND DEVICE FOR MANUFACTURING THE TUBE</u>		
(54) 発明の名称 内面溝付伝熱管およびその製造方法並びに製造装置		
(57) Abstract A heat transfer tube with internal grooves, wherein multiple rows of V-shaped streaky grooves (3), (3) --- are formed in the inner peripheral surface (2) of a tube main body (1a) symmetrically with respect to the axial direction of the tube and secondary grooves (6), (6), ---, (7), (7) --- of a specified depth are formed in a part of projected streaky parts (5), (5), --- formed between the V-shaped streaky grooves to reduce a pressure loss, and the width of the multiple rows of the V-shaped streaky grooves (3), (3), --- in circumferential direction is differentiated from each other to produce a swirl component in spiral direction, whereby the flow of refrigerant in the tube can be controlled properly even when a refrigerant flow rate is small to increase a heat transfer performance as large as possible.		

